The Expansive Plane and the Anatomy of Singularities

A geometric conjecture on expansion, dimensionality, and the perception of space-time

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1 Introduction

Unlike traditional cosmological models, in which space, time, and dimensionality are treated as fundamental properties of the universe, the present conjecture proposes that such properties emerge from expansive relations between elementary geometric units.

The model is based on a central principle:

> Every perception of expansion, contraction, or stability depends on the scale of measurement used by the observer.

Thus, a universe undergoing absolute homogeneous expansion would be indistinguishable from a static universe for internal observers, since all units of measurement would also undergo proportional expansion.

This idea presents conceptual parallels with General Relativity, especially in the way measurements of space and time depend on the observer's frame of reference and on the local geometry of space-time.

General Relativity describes the geometry of space-time through the field equations:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{1}$$

where:

- $G_{\mu\nu}$ represents the curvature of space-time;
- Λ represents the cosmological constant;
- $g_{\mu\nu}$ represents the space-time metric;
- $T_{\mu\nu}$ represents the energy-momentum tensor.

In modern cosmology, the expansion of the universe is described by the cosmological scale factor $a(t)$:

$$d(t) = a(t) d_0 \tag{2}$$

where:

- d_0 represents an initial distance;

- $d(t)$ represents the observed distance throughout cosmological time.

However, the conjecture presented here proposes an interpretative extension of this concept: not only do distances expand, but the very fundamental geometric units themselves could undergo heterogeneous deformations depending on the observed region of space-time.

This interpretation seeks to explain why certain cosmological phenomena appear to possess temporal scales incompatible with traditional models of structural evolution in the universe.

In recent years, observations conducted by the James Webb Space Telescope (JWST) have revealed extremely developed structures at very primitive epochs of cosmological history, raising important questions regarding the rate of formation of galaxies, stars, and massive gravitational singularities.

Among the most relevant observations are:

- structurally mature galaxies formed only a few hundred million years after the Big Bang;
- detection of supermassive black holes whose mass exceeds billions of solar masses at extremely early epochs of the observable universe;
- cosmological structures whose gravitational organization appears to require evolutionary timescales longer than those predicted by traditional cosmological models;
- observations of extremely luminous primordial quasars associated with already fully developed active galactic nuclei.

One of the most relevant examples was the observation of the primordial quasar designated QSO1, whose light underwent gravitational lensing caused by the galaxy cluster Abell 2744, known as the "Pandora Cluster".

The gravitational lensing effect occurs when large concentrations of mass deform the geometry of space-time, deflecting light trajectories as predicted by General Relativity:

$$\alpha = \frac{4GM}{c^2 b} \tag{3}$$

where:

- α represents the gravitational deflection angle;

- G represents the gravitational constant;
- M represents the mass of the body responsible for the curvature;
- c represents the speed of light;
- b represents the impact parameter of the light trajectory.

Due to the intense gravitational deformation caused by the Abell 2744 cluster, the James Webb Space Telescope recorded multiple images of the same primordial cosmological object, allowing the observation of extremely ancient structures with unprecedented resolution.

These observations become particularly relevant to the Expansive Plane conjecture because they suggest that:

- massive gravitational structures may arise much earlier than predicted;
- primitive regions of the universe may have evolved under distinct temporal dynamics;
- the initial cosmological expansion may not have occurred in a completely homogeneous manner.

Furthermore, the JWST also detected massive galaxies with intense star formation rates in periods shorter than 500 million years after the Big Bang, something that directly challenges traditional models of gradual gravitational accretion.

The rate of cosmological expansion is traditionally described by the Hubble parameter:

$$H(t) = \frac{\dot{a}(t)}{a(t)} \tag{4}$$

where:

- $a(t)$ represents the cosmological scale factor;
- $\dot{a}(t)$ represents its temporal derivative;
- $H(t)$ represents the instantaneous expansion rate of the universe.

In the traditional formulation of cosmology, isotropy and large-scale homogeneity are assumed, as described by the Friedmann-Lemaître-Robertson-Walker (FLRW)

metric. However, recent observations raise the possibility that the primordial universe may have exhibited locally anisotropic regions or distinct effective temporal regimes.

Within the Expansive Plane conjecture, one possible speculative interpretation would be that:

> the effective temporal flow itself could vary according to the local expansive geometric state of primordial space-time.

This would imply that certain regions could exhibit accelerated structural evolution under specific internal frames of reference, allowing the early formation of:

- massive galaxies;
- gravitational clusters;
- primordial quasars;
- supermassive black holes.

Another relevant observation involves the so-called "Little Red Dots", extremely compact and reddish objects detected by the JWST, whose nature still remains partially undefined. Some hypotheses suggest that such structures may represent extremely ancient active galactic nuclei containing supermassive singularities undergoing accelerated growth.

The existence of these structures reinforces the possibility that:

- the primordial universe may have evolved under geometric conditions not yet fully understood;
- heterogeneous expansion effects may have directly influenced the initial structural formation;
- gravitational singularities may possess a more fundamental cosmological role than predicted by traditional models.

In this context, the Expansive Plane proposes that space, time, and dimensionality would not be absolutely static properties, but rather emergent geometric states associated with the expansive dynamics of the primordial universe itself.

Within the conceptual framework of the Expansive Plane, one possible speculative interpretation would be that primordial regions of the universe could exhibit different effective regimes of temporal and spatial expansion.

Relativistic time dilation can be described by the equation:

$$\Delta t' = \Delta t \sqrt{1 - \frac{2GM}{rc^2}} \tag{5}$$

where:

- $\Delta t'$ represents the time observed under gravitational influence;
- Δt represents time in a distant frame of reference;
- G represents the gravitational constant;
- M represents the mass of the body;
- r represents the distance to the gravitational center;
- c represents the speed of light.

The conjecture proposes that analogous effects could exist not only in local singularities, but also in primordial cosmological states, where the geometry of space-time would still be dynamically emerging.

From this initial axiom, the documents develop two complementary structures:

- the **Expansive Plane**, responsible for the emergence of dimensions and for the expansion of space-universe;
- and the **Anatomy of Singularities**, which seeks to reinterpret gravitational singularities as regions where spatial and temporal units become progressively deformed relative to the external observer.

2 The Expansive Plane

2.1 Expansion as the Origin of Dimensionality

The Expansive Plane proposes that dimensions are not static properties of the universe, but emergent geometric states associated with the very process of expansion.

In this geometric model, space-time is not treated as a rigid and previously defined structure, but rather as a dynamic expansive system whose own dimensionality progressively emerges according to the local expansive state.

The expansive plane can be represented by an anisotropic geometric lattice, in which certain regions undergo differential deformations along their structural axes.

In these regions, the fundamental geometric units become progressively compressed or dilated depending on the observed direction.

Mathematically, the local expansive gradient may be represented through a position-dependent metric:

$$ds^2 = g_{ij}(x, y, t)\, dx^i dx^j \tag{6}$$

where:

- $g_{ij}(x, y, t)$ represents the local metric of the expansive plane;
- x and y represent spatial coordinates;
- t represents the temporal expansive state.

Within the expansive lattice, regions near the central axes exhibit approximately homogeneous expansion:

$$\frac{\partial g_{xx}}{\partial x} \approx \frac{\partial g_{yy}}{\partial y} \tag{7}$$

Whereas peripheral regions exhibit anisotropic deformations:

$$\frac{\partial g_{xx}}{\partial x} \neq \frac{\partial g_{yy}}{\partial y} \tag{8}$$

This geometry produces behavior similar to that observed in the matrix-like sketches of the expansive plane, where:

- central regions preserve geometric proportionality;
- regions near the boundaries exhibit differential compressions;
- geometric density increases as certain coordinates asymptotically approach limiting regions.

The expansive lattice may be interpreted as a simplified discrete representation of a variable metric geometry, in which the effective distance between fundamental units changes according to the local expansive state.

A fundamental expansive function is then defined:

$$\Gamma(x, y, t) = \frac{\partial \Phi(x, y, t)}{\partial t} \tag{9}$$

where:

- $\Gamma(x, y, t)$ represents the local expansive rate;
- $\Phi(x, y, t)$ represents the expansive geometric potential of the plane.

In this formulation, different regions of the space-universe may evolve under distinct expansive rates, producing:

- local metric deformations;
- cosmological anisotropies;
- effective temporal gradients;
- emergent gravitational curvatures.

The effective dimensionality of space-time may then be treated as an emergent property of expansive dynamics:

$$D_{\text{effective}} = D_0 + \int_{\Omega} \Gamma(x, y, t)\, d\Omega \tag{10}$$

where:

- D_0 represents the minimum dimensional state;
- Ω represents the analyzed geometric region;
- $\Gamma(x, y, t)$ represents the local expansive density.

Under this interpretation, dimensions do not arise instantaneously as absolute properties of the universe, but progressively emerge as expansive geometry evolves.

This behavior presents conceptual parallels with modern approaches to quantum gravity, especially models in which:

- effective dimensionality varies across different energy scales;
- space and time emerge from more fundamental geometric structures;
- the geometry of the primordial universe does not necessarily obey classical continuous metrics.

The traditional cosmological expansion may be described by the Friedmann Equation:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3} \tag{11}$$

However, within the expansive model, the scale factor ceases to be globally homogeneous and instead becomes locally dependent on the geometry of the lattice:

$$a \to a(x, y, t) \tag{12}$$

This implies that different regions of the primordial universe could exhibit:

- distinct rates of structural evolution;
- different effective temporal regimes;
- distinct velocities of gravitational formation;
- variable dimensional densities.

Under this interpretation, extremely early cosmological structures observed by the James Webb Space Telescope could represent regions where the local expansive gradient favored accelerated processes of gravitational organization.

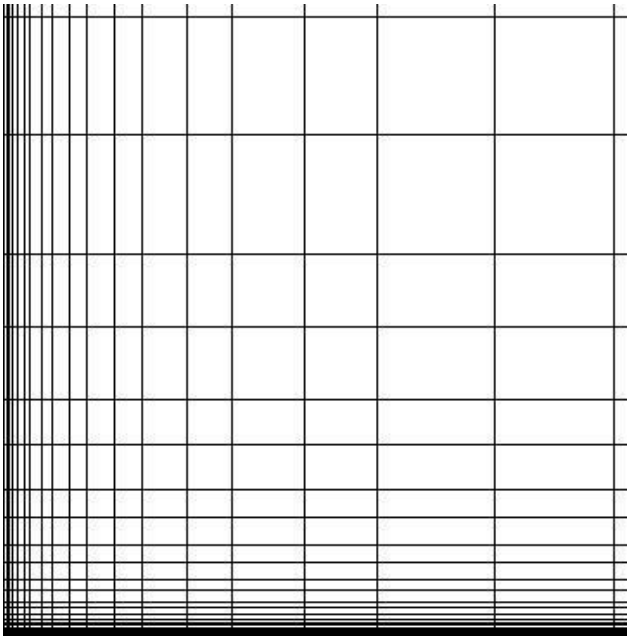

Figure 1: Schematic representation of the Expansive Plane lattice. An anisotropic geometry is observed in which different regions of space exhibit distinct metric densities. Near regions of geometric compression, the fundamental units become progressively smaller, producing an increase in effective spatial density and local deformations in the space-time metric. The model suggests that such expansive gradients may be associated with the emergence of gravitational curvatures, distinct temporal regimes, and the early formation of massive cosmological structures.

The geometry of the lattice itself suggests that regions near zones of metric compression would naturally tend toward the formation of:

- gravitational singularities;
- regions of high energy density;
- extreme curvatures of space-time;
- massive cosmological structures during primitive epochs.

Traditional cosmological expansion is described by the Friedmann Equation:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3} \tag{13}$$

where:

- $a(t)$ represents the scale factor of the universe;
- ρ represents the energy density;
- k represents spatial curvature;
- Λ represents the cosmological constant.

The formulation presented here proposes a geometric extension of traditional cosmological dynamics, suggesting that the expansion of the universe acts not exclusively upon metric distances, but also upon the very dimensional structure of space-time.

This interpretation finds conceptual parallels in different contemporary approaches to theoretical physics, especially in models of quantum gravity, emergent geometry, and variable dimensionality at high energy scales. In several modern formulations, space and time cease to be treated as fundamentally continuous entities, instead emerging from more elementary geometric structures.

Within this perspective, central regions of the expansive lattice would tend to exhibit approximately homogeneous behavior:

$$\frac{\partial a}{\partial x} \approx \frac{\partial a}{\partial y} \tag{14}$$

while peripheral regions could evolve under anisotropic gradients:

$$\frac{\partial a}{\partial x} \neq \frac{\partial a}{\partial y} \tag{15}$$

This behavior presents mathematical similarities to anisotropic solutions of Bianchi cosmological metrics, in which different spatial axes evolve under distinct expansion rates:

$$ds^2 = -dt^2 + a_x^2(t)\,dx^2 + a_y^2(t)\,dy^2 + a_z^2(t)\,dz^2 \tag{16}$$

where:

- $a_x(t)$, $a_y(t)$, and $a_z(t)$ represent independent scale factors;
- different spatial directions may undergo differential expansion.

In modern cosmology, small primordial anisotropies are already empirically observed through fluctuations in the Cosmic Microwave Background (CMB), detected by missions such as COBE, WMAP, and Planck.

The temperature variations observed in the cosmic background may be expressed by:

$$\frac{\Delta T}{T} \sim 10^{-5} \tag{17}$$

indicating that the primordial universe was not perfectly homogeneous.

Within the expansive geometric model, such anisotropies could represent manifestations of local gradients in metric density and differential expansion in the primordial universe.

Under this interpretation:

- geometrically more compressed regions would tend toward an increase in local energy density;
- expansive gradients could induce gravitational curvatures;
- local metric differences could directly influence effective temporal flow;
- massive cosmological structures could preferentially emerge in regions of geometric compression.

The curvature of space-time remains compatible with the tensorial formulation of General Relativity:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu} \tag{18}$$

However, in this formulation, the metric tensor $g_{\mu\nu}$ no longer represents merely a classical continuous geometry, but instead reflects a dynamic expansive structure whose geometric density may vary locally.

This approach becomes conceptually close to modern proposals such as:

- emergent geometry;
- causal dynamical triangulations;
- loop quantum gravity;
- gravitational holography;
- dimensional reduction at high energies;
- discrete space-time.

The effective dimensionality of space-time may then be described as a function of the local expansive state:

$$D_{\text{effective}} = f(\Gamma, \rho, E, t) \tag{19}$$

where:

- Γ represents the local expansive gradient;
- ρ represents the energy density;
- E represents the energy scale;
- t represents the temporal cosmological state.

Under this mathematical structure, space, time, and dimensionality become interpreted as different observable manifestations of the same fundamental expansive geometric process.

- central regions expand in an approximately homogeneous manner;
- while peripheral regions become geometrically eccentric or anisotropic.

This idea establishes a possible relationship between:

- expansion;
- curvature;
- emergent dimensionality.

Conceptually, this hypothesis approaches contemporary models of:

- emergent dimensions;
- non-Euclidean geometry;
- modern theories of quantum gravity.

2.2 The Infinitesimal Plane

The model divides cosmological structure into two fundamental geometric regions.

2.2.1 Expansive Space-Universe

Region where space, curvature, and dimensionality dynamically emerge from the evolution of the expansive lattice.

2.2.2 Infinitesimal Plane

Primordial geometric region associated with states of extreme metric compression, where multiple spatial structures may coexist at asymptotically reduced scales.

The central problem introduced by this formulation consists of understanding how a geometrically limited structure may contain arbitrarily high degrees of spatial complexity.

Mathematically, this interpretation approaches fractal structures, compactified manifolds, and geometric models in which information density grows more rapidly than the apparent volume of the observed region.

Within this framework, the space-universe may be represented as an expansive matrix lattice, where each matrix element represents a fundamental geometric unit of space-time.

In its most elementary state, the system may be described by a minimal matrix:

$$M_{2\times 2} = \begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \end{bmatrix} \tag{20}$$

where each element μ_{ij} represents a fundamental geometric unit associated with the local metric state of space.

As the system evolves expansively, new rows and columns may dynamically emerge:

$$M_{2\times 3} = \begin{bmatrix} \mu_{11} & \mu_{12} & \mu_{13} \\ \mu_{21} & \mu_{22} & \mu_{23} \end{bmatrix} \tag{21}$$

$$M_{2\times 4} = \begin{bmatrix} \mu_{11} & \mu_{12} & \mu_{13} & \mu_{14} \\ \mu_{21} & \mu_{22} & \mu_{23} & \mu_{24} \end{bmatrix} \tag{22}$$

or alternatively:

$$M_{3\times 2} = \begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \\ \mu_{31} & \mu_{32} \end{bmatrix} \tag{23}$$

$$M_{4\times 2} = \begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \\ \mu_{31} & \mu_{32} \\ \mu_{41} & \mu_{42} \end{bmatrix} \tag{24}$$

In more complex expansive states, matrix growth may occur simultaneously across multiple axes:

$$M_{3\times 3} = \begin{bmatrix} \mu_{11} & \mu_{12} & \mu_{13} \\ \mu_{21} & \mu_{22} & \mu_{23} \\ \mu_{31} & \mu_{32} & \mu_{33} \end{bmatrix} \tag{25}$$

$$M_{4\times 4} = \begin{bmatrix} \mu_{11} & \mu_{12} & \mu_{13} & \mu_{14} \\ \mu_{21} & \mu_{22} & \mu_{23} & \mu_{24} \\ \mu_{31} & \mu_{32} & \mu_{33} & \mu_{34} \\ \mu_{41} & \mu_{42} & \mu_{43} & \mu_{44} \end{bmatrix} \tag{26}$$

$$M_{N\times M} = \begin{bmatrix} \mu_{11} & \cdots & \mu_{1M} \\ \vdots & \ddots & \vdots \\ \mu_{N1} & \cdots & \mu_{NM} \end{bmatrix} \tag{27}$$

id="w6ytqf" Under this formulation, dimensional increase ceases to be interpreted merely as continuous metric expansion, instead representing structural growth of geometric space itself.

A dimensional growth function is then defined:

$$D(t) = \dim(M_{N\times M}(t)) \tag{28}$$

where:

- $D(t)$ represents the effective dimensionality of the system;
- $M_{N\times M}(t)$ represents the matrix state of the expansive lattice throughout cosmological time.

Matrix growth may be described by the relation:

$$\frac{dM}{dt} = \Gamma(M, \rho, E) \tag{29}$$

where:

- Γ represents the geometric expansive potential;
- ρ represents the local energy density;
- E represents the energy scale of the system.

Under this interpretation, dimensions progressively emerge as new geometric states become accessible to the expansive system.

This approach presents conceptual parallels with:

- tensor networks;
- discrete geometry;
- causal dynamical triangulations;
- spin networks in loop quantum gravity;
- emergent holographic structures;
- discrete space-time models.

Under regimes of extreme compression, the effective spacing between lattice elements asymptotically approaches infinitesimal values:

$$\lim_{\Delta x \to 0} N(\Delta x) \to \infty \tag{30}$$

where:

- Δx represents the local metric scale;
- $N(\Delta x)$ represents the effective number of geometric units contained within the analyzed region.

This implies that a geometrically limited region may contain an arbitrarily large amount of internal structure, conceptually approaching:

- dimensional compactification;
- fractal geometry;

- metric singularities;
- holographic principles of informational density.

Thus, the infinitesimal plane ceases to represent merely a singular geometric point, instead behaving as a region of extreme structural density, where space, dimensionality, and curvature become progressively indistinguishable.

An infinitely irregular surface could contain an arbitrarily large quantity of "internal space," even while externally occupying a limited area.

This interpretation brings the conjecture conceptually closer to contemporary ideas such as:

- fractal geometry;
- the holographic principle;
- dimensional compactification;
- hyperdimensional manifolds.

3 Anatomy of Singularities

3.1 Heterogeneous Expansion and Physical Perception

The second part of this conjecture introduces a fundamental element:

> The perception of expansion depends on the heterogeneity of spatial units.

Thus:

- different regions of space may expand at different rates;
- causing observers to perceive expansion, contraction, or temporal distortion in distinct ways.

This formulation may be represented geometrically through local matrix lattices subjected to different expansive tensors.

Consider initially an idealized homogeneous lattice:

$$M_0 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \tag{31}$$

In this state, all geometric units possess equivalent metric density, implying local spatial isotropy.

However, under heterogeneous expansion, different regions begin to evolve under distinct expansive factors:

$$M(t) = \begin{bmatrix} a_{11}(t) & a_{12}(t) & a_{13}(t) \\ a_{21}(t) & a_{22}(t) & a_{23}(t) \\ a_{31}(t) & a_{32}(t) & a_{33}(t) \end{bmatrix} \tag{32}$$

where each element $a_{ij}(t)$ represents the local expansive state of a fundamental geometric unit.

If certain regions expand more rapidly:

$$a_{11}(t) < a_{22}(t) < a_{33}(t) \tag{33}$$

then the effective geometric density becomes spatially non-uniform.

One may define the local metric density as:

$$\rho_{ij} = \frac{1}{a_{ij}(t)} \tag{34}$$

Thus:

- regions of lower expansion exhibit higher geometric density;
- regions of greater expansion exhibit lower effective metric density.

This distribution produces spatial gradients capable of inducing local deformations in the space-time metric.

The effective geometry of the system may then be represented by a discrete metric tensor:

$$g_{ij} = \begin{bmatrix} \rho_{11} & 0 & 0 \\ 0 & \rho_{22} & 0 \\ 0 & 0 & \rho_{33} \end{bmatrix} \tag{35}$$

In this model, local curvature naturally emerges from differences between adjacent geometric densities:

$$\Delta\rho = \rho_{i+1,j} - \rho_{ij} \tag{36}$$

When:

$$\Delta\rho \neq 0 \tag{37}$$

the lattice ceases to be geometrically flat, producing local metric deformations. This structure presents mathematical parallels with:

- curvature tensors in General Relativity;
- discrete quantum gravity networks;
- causal dynamical triangulations;
- lattice models of discrete space-time.

Local temporal perception also becomes dependent upon regional geometric density.

A local effective time is then defined:

$$\tau_{ij} = \frac{t}{\rho_{ij}} \tag{38}$$

where:

- τ_{ij} represents the effectively perceived time in the region;
- t represents global cosmological time;
- ρ_{ij} represents the local geometric density.

Under this formulation:

- geometrically denser regions exhibit effective time dilation;
- less dense regions evolve temporally in a more accelerated manner.

This produces a scenario in which different regions of the primordial universe could evolve under distinct temporal rhythms.

Consider, for example, two sectors of the lattice:

$$M_A = \begin{bmatrix} 0.2 & 0.2 \\ 0.2 & 0.2 \end{bmatrix} \qquad M_B = \begin{bmatrix} 2.0 & 2.0 \\ 2.0 & 2.0 \end{bmatrix} \tag{39}$$

In sector M_A, the geometric units are compressed, producing high metric density: id="o8rf4p"

$$\rho_A = \frac{1}{0.2} = 5 \tag{40}$$

While in sector M_B:

$$\rho_B = \frac{1}{2.0} = 0.5 \tag{41}$$

Consequently:

$$\tau_A < \tau_B \tag{42}$$

implying distinct effective temporal rhythms between geometrically different regions.

Under this interpretation:

- compressed regions would tend toward accelerated gravitational formation;
- dilated regions would exhibit lower structural density;
- expansive anisotropies could induce cosmological temporal differences;
- gravitational singularities could emerge as extreme limits of geometric density.

This approach provides a possible mathematical framework for interpreting:

- the early formation of supermassive black holes;
- accelerated growth of primitive galaxies;
- cosmological anisotropies;
- distinct effective temporal regimes in the primordial universe.

At extreme scales, the lattice may approach asymptotic states where:

$$\lim_{a_{ij} \to 0} \rho_{ij} \to \infty \tag{43}$$

producing regions of extreme geometric compression compatible with gravitational singularities or states of metric compactification of space-time.

This formulation may be represented geometrically through local matrix lattices subjected to different expansive tensors.

Consider initially an idealized homogeneous lattice:

$$M_0 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \tag{44}$$

In this state, all geometric units possess equivalent metric density, implying local spatial isotropy.

However, under heterogeneous expansion, different regions begin to evolve under distinct expansive factors:

$$M(t) = \begin{bmatrix} a_{11}(t) & a_{12}(t) & a_{13}(t) \\ a_{21}(t) & a_{22}(t) & a_{23}(t) \\ a_{31}(t) & a_{32}(t) & a_{33}(t) \end{bmatrix} \tag{45}$$

where each element $a_{ij}(t)$ represents the local expansive state of a fundamental geometric unit.

If certain regions expand more rapidly:

$$a_{11}(t) < a_{22}(t) < a_{33}(t) \tag{46}$$

then the effective geometric density becomes spatially non-uniform.

One may define the local metric density as:

$$\rho_{ij} = \frac{1}{a_{ij}(t)} \tag{47}$$

Thus:

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- regions of greater expansion exhibit lower effective metric density.

This distribution produces spatial gradients capable of inducing local deformations in the space-time metric.

The effective geometry of the system may then be represented by a discrete metric tensor:

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In this model, local curvature naturally emerges from differences between adjacent geometric densities:

$$\Delta\rho = \rho_{i+1,j} - \rho_{ij} \tag{49}$$

When:

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the lattice ceases to be geometrically flat, producing local metric deformations. This structure presents mathematical parallels with:

- curvature tensors in General Relativity;
- discrete quantum gravity networks;
- causal dynamical triangulations;
- lattice models of discrete space-time.

Local temporal perception also becomes dependent upon regional geometric density.

A local effective time is then defined:

$$\tau_{ij} = \frac{t}{\rho_{ij}} \tag{51}$$

where:

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- t represents global cosmological time;
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Under this formulation:

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In sector M_A, the geometric units are compressed, producing high metric density:

$$\rho_A = \frac{1}{0.2} = 5 \tag{53}$$

While in sector M_B:

$$\rho_B = \frac{1}{2.0} = 0.5 \tag{54}$$

Consequently:

$$\tau_A < \tau_B \tag{55}$$

implying distinct effective temporal rhythms between geometrically different regions.

Under this interpretation:

- compressed regions would tend toward accelerated gravitational formation;
- dilated regions would exhibit lower structural density;
- expansive anisotropies could induce cosmological temporal differences;
- gravitational singularities could emerge as extreme limits of geometric density.

This approach provides a possible mathematical framework for interpreting:

- the early formation of supermassive black holes;
- accelerated growth of primitive galaxies;
- cosmological anisotropies;
- distinct effective temporal regimes in the primordial universe.

At extreme scales, the lattice may approach asymptotic states where:

$$\lim_{a_{ij} \to 0} \rho_{ij} \to \infty \tag{56}$$

producing regions of extreme geometric compression compatible with gravitational singularities or states of metric compactification of space-time.

In this context:

- space and time become inseparable properties;
- gravitational singularities become interpreted as extreme regions of metric deformation.

3.2 Singularities as Asymptotic Boundaries

Thus, singularities are described not necessarily as absolute physical points, but as boundary-regions where:

- spatial units become progressively smaller;
- the number of units required to traverse a region tends toward infinity;
- the observer asymptotically approaches a boundary that is never completely reached.

This interpretation possesses conceptual parallels with:

- event horizons;
- relativistic time dilation;
- asymptotic geometries in General Relativity.

3.3 Hollow Singularities

Another conjectural idea proposes that singularities could possess internal structures decoupled from the external universe.

According to this interpretation:

Another geometry considered consists in the possibility that gravitational singularities may present internal regions dynamically decoupled from observable external space-time.

Thus, singularities cease to be interpreted exclusively as points of infinite density, instead behaving as boundary-regions where the very metric structure of space-time undergoes extreme geometric transitions.

Under certain critical conditions of spatial compression and gravitational acceleration, the system would tend to approach an asymptotic regime in which:

- local geometric density grows rapidly;
- time dilation becomes dominant;
- causal trajectories undergo extreme deformations;
- external observers lose effective causal access to internal regions.

Classical gravitational acceleration may be described by:

$$a(r) = \frac{GM}{r^2} \tag{57}$$

where:

- $a(r)$ represents local gravitational acceleration;
- G represents the gravitational constant;
- M represents the mass of the singularity;
- r represents the radial distance to the gravitational center.

However, in extreme relativistic regimes, the geometry of space-time becomes dominated by the Schwarzschild metric:

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right)c^2dt^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1}dr^2 + r^2d\Omega^2 \tag{58}$$

The critical radius associated with the gravitational horizon is given by:

$$r_s = \frac{2GM}{c^2} \tag{59}$$

When:

$$r \to r_s \tag{60}$$

time dilation asymptotically tends toward infinity:

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{2GM}{rc^2}}} \tag{61}$$

implying that, for external observers, physical processes near the horizon appear to slow indefinitely.

Within this geometric framework, this condition may be reinterpreted as a regime in which the expansive lattice undergoes extreme metric compression.

A radial geometric density is then defined:

$$\rho_g(r) = \frac{1}{1 - \frac{2GM}{rc^2}} \tag{62}$$

Thus:

$$\lim_{r \to r_s} \rho_g(r) \to \infty \tag{63}$$

Under this formulation, regions near the gravitational horizon would tend to exhibit:

- extreme increase in geometric density;
- effective contraction of spatial units;
- progressive causal decoupling;
- internal metric reorganization.

One may further consider a critical regime associated with maximum causal acceleration.

Relativistic escape velocity is given by:

$$v_e = \sqrt{\frac{2GM}{r}} \tag{64}$$

When:

$$v_e \geq c \tag{65}$$

one obtains:

$$r \leq \frac{2GM}{c^2} = r_s \tag{66}$$

indicating that no classical causal trajectory can escape the internal region.

However, the proposed geometric formulation interprets this condition not merely as gravitational confinement, but as a possible structural rupture between different metric domains of space-time.

In this regime, external causal flow would asymptotically tend toward interruption:

$$\lim_{r \to r_s} \frac{d\tau}{dt} \to 0 \tag{67}$$

where:

- τ represents internal proper time;
- t represents the time of the external observer.

This implies that, under external frames of reference, internal regions become progressively temporally inaccessible.

Within this interpretation, the singularity may behave as a geometric boundary between different metric regimes.

The internal expansive lattice could then reorganize itself according to new geometric conditions:

$$M_{\text{internal}} \neq M_{\text{external}} \tag{68}$$

allowing:

- internal structures to evolve causally decoupled;
- new temporal regimes to emerge;
- different dimensional densities to coexist;
- independent geometric domains to be formed.

This mathematical structure also becomes conceptually close to models in which singularities do not represent absolute physical points, but rather geometric transitions between different metric states of space-time.

Under this formulation, internal regions could evolve according to their own dynamics, potentially inaccessible to the external universe due to causal decoupling induced by extreme geometric compression of the expansive lattice.

4 Contemporary Connections

Recent observations of the primordial universe carried out by the James Webb Space Telescope revealed:

- mature galaxies at extremely ancient epochs;
- early supermassive black holes.

These observations challenge traditional cosmological models, since there would apparently not have been sufficient time for the growth of such structures.

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> Primordial regimes of the universe could possess effective temporal scales different from those observed today.

If space, time, and dimensionality emerge jointly from heterogeneous expansion, then:

- initial regions of the universe could exhibit radically distinct temporal dynamics;
- allowing accelerated structural growth under specific internal frames of reference.

5 Preliminary Mathematical Discussions

A possible future formalization of the conjecture would require tools from different areas of mathematics and theoretical physics, including:

- differential geometry;
- topology;
- tensor theory;
- General Relativity;
- fractal geometry;
- holographic theory;
- quantum gravity.

The results developed throughout this work suggest a possible geometric framework capable of connecting cosmological expansion, metric anisotropies, emergent dimensionality, and extreme gravitational regimes within a single conceptual formulation.

The approach presented describes space-time as a dynamic expansive system, in which properties traditionally treated as fundamental — such as distance, dimensionality, and temporal flow — instead emerge from the local geometric evolution of the expansive lattice.

Within this structure, phenomena associated with primordial cosmology, the early formation of massive structures, and gravitational singularities may be reinterpreted as manifestations of heterogeneous expansive gradients and variable metric densities.

The matrix models introduced throughout this work provide a simplified geometric representation for describing:

- differential expansion of space-time;
- dynamic evolution of effective dimensionality;
- local regimes of geometric compression;
- metric transitions associated with gravitational singularities.

The formulations presented maintain conceptual compatibility with already established structures in modern physics, including:

- General Relativity;
- relativistic cosmology;
- anisotropic geometries;
- quantum gravity;
- discrete space-time;
- gravitational holography;
- emergent models of variable dimensionality.

Furthermore, recent observations obtained by the James Webb Space Telescope, involving highly developed primitive galaxies, extremely ancient quasars, and supermassive black holes during early epochs of the universe, reinforce the relevance of models capable of describing non-homogeneous cosmological regimes during the first stages of universal evolution.

Within this interpretation, cosmological expansion ceases to represent merely the uniform increase of spatial distances, instead corresponding to a broader geometric process capable of locally altering:

- metric densities;
- effective temporal rhythms;
- dimensional degrees of freedom;
- causal properties of space-time.

The results also suggest that gravitational singularities may be treated not only as mathematical limits of General Relativity, but also as possible geometric transitions between different structural regimes of space-time.

Under this perspective, extreme gravitational horizons could induce causal decouplings, internal metric reorganizations, and highly compactified geometric states, conceptually approaching modern models involving baby universes, holographic structures, and emergent geometries.

Although several mathematical stages still require rigorous formalization, the developed structure establishes a coherent conceptual framework for future extensions involving:

- differential geometry;
- tensor theory;
- dynamics of geometric networks;
- discrete space-time models;
- quantum gravity;
- primordial cosmology.

The proposed formulation suggests that space, time, dimensionality, and gravity may represent distinct manifestations of a single fundamental expansive geometric dynamics, whose local evolution determines the observable structural organization of the universe.

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